PLASMA AN ION engines

https://descanso.jpl.nasa.gov/SciTechBook/series1/Goebel__cmprsd_opt.pdf
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http://www.unoosa.org/documents/pdf/psa/hsti/CostaRica2016/2-4.pdf
https://phys.org/news/2015-03-revolutionary-ion-spacecraft-ceres.html
these are plasma ion engines
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https://www.aps.org/units/dfd/meetings/upload/Gallimore_APSDFD08.pdf
https://www.nasa.gov/centers/glenn/technology/Ion_Propulsion1.html
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https://en.wikipedia.org/wiki/Plasma_propulsion_engine

https://www.nasa.gov/centers/glenn/about/fs21grc.html

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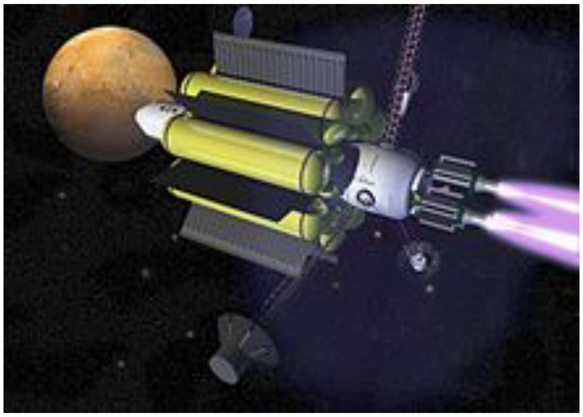
A thruster during test firing



Artist rendition of VASIMR plasma engine

A **plasma propulsion engine** is a type of electric propulsion that generates thrust from a quasi-neutral plasma. This is in contrast to ion thruster engines, which generate thrust through extracting an ion current from the plasma source, which is then accelerated to high velocities using grids/anodes. These exist in many forms (see electric propulsion). Plasma thrusters do not typically use high voltage grids or anodes/cathodes to accelerate the charged particles in the plasma, but rather uses currents and potentials which are generated internally in the plasma to accelerate the plasma ions. While this results in a lower exhaust velocity by virtue of the lack of high accelerating voltages, this type of thruster has a number of advantages. The lack of high voltage grids of anodes removes a possible limiting element as a result of grid ion erosion. The plasma exhaust is 'quasi-neutral', which means that ions and electrons exist in equal number, which allows simple ion-electron recombination in the exhaust to neutralize the exhaust plume, removing the need for an electron gun (hollow cathode). This type of thruster often generates the source plasma using radio frequency or microwave energy, using an external antenna. This fact, combined with the absence of hollow cathodes (which are very sensitive to all but the few noble gases) allows the intriguing possibility of being able to use this type of thruster on a huge range of propellants, from argon, to carbon dioxide, air mixtures, to astronaut urine.[1]

Plasma engines are better suited for long-distance interplanetary space travel missions.[2]

In recent years, many agencies have developed several forms of plasma-fueled engines, including the European Space Agency, Iranian Space Agency and Australian National University, which have co-developed a more advanced type described as a double layer thruster.[3][4] However, this form of plasma engine is only one of many type

RF resonant cavity thruster

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For thrusters that use electrical power to change the velocity of spacecraft, see Electrically-powered spacecraft propulsion. For rocket that uses thrust from the momentum of emitted photons, see Photon rocket.

A **radio frequency** (**RF**) **resonant cavity thruster** is a device concept that is claimed to be a spacecraft thruster.[1][2] It is purported to generate thrust by reflecting microwaves internally in the device, in violation of the law of conservation of momentum and other laws of physics.[3][4][5][6][7][8][9][10] The device is also known as an **EmDrive** and has been often referred to by the media as the **Impossible Drive**.[11][12][13][7] It was introduced in 2001 by Roger Shawyer.[14][15]

There exists no official design for this device, and neither of the people who claim to have invented it have committed to an explanation for how it could operate as a thruster or what elements define it, making it difficult to tell whether a given object is an example of such a device. However, several prototypes based on its public descriptions have been constructed and tested. In 2016, the Advanced Propulsion Physics Laboratory at NASA reported observing a small apparent thrust from one such test,[16] a result not since replicated. No other published experiment has measured apparent thrust greater than the experiment's margin of error.[17]